

G.3 Use of ILAW Performance Assessment Calculations in Potential HSW EIS Long-Term Groundwater Quality and Human Health Impacts

Potential impact results presented for the ILAW disposal facility were based on performance assessment (PA) calculations made for siting the facility in the vicinity of the PUREX Plant, as summarized in Mann et al. (2001). The following section discusses:

- range of waste form and engineering performance examined to date, as discussed in Mann et al. (2001) including the specific discussion of the case selected for this analysis
- additional planned analyses of waste disposal system performance
- scaling of ILAW PA results for use in this analysis.

G.3.1 Range of Waste Form and Engineering Performance Evaluated in the 2001 ILAW Performance Assessment

The potential long-term impacts from disposing ILAW was analyzed in the *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001* (Mann et al. 2001), known as 2001 ILAW PA. A wide variety of cases were analyzed. Performance objectives covering air, groundwater, surface water, all-pathways, and inadvertent intrusion were established based on analyzing applicable and relevant regulations. The document concluded that there was a reasonable expectation that long-term public health and safety as well as the environment would be protected from the disposal in dirt trenches of a vitrified product from the Waste Treatment Plant (WTP). This document was reviewed by the Washington State Department of Ecology and approved by DOE headquarters, in accordance with DOE (2001).

The 2001 ILAW PA was built around a base analysis case. This case was designed to include the major features of disposal facility design and performance without going into details that have minimal impact in long-term performance. Important features are the waste composition and facility design.

At the time of writing the 2001 ILAW PA, the reference glasses to be produced by the WTP were not specified. Therefore, the ILAW PA activity used a glass composition (LAWABP1) developed by the Pacific Northwest National Laboratory in the composition envelope within which the WTP was working because of extensive laboratory testing data base for LAWABP1. Subsequent testing of the WTP reference glasses shows that the performance of LAWABP1 is very comparable to the WTP reference glasses. The results of the base analysis case, along with other cases analyzed, are illustrated in Figure G.95 as the curve labeled LAWABP1. Results of this case are also presented in tabular form in Table G.40.

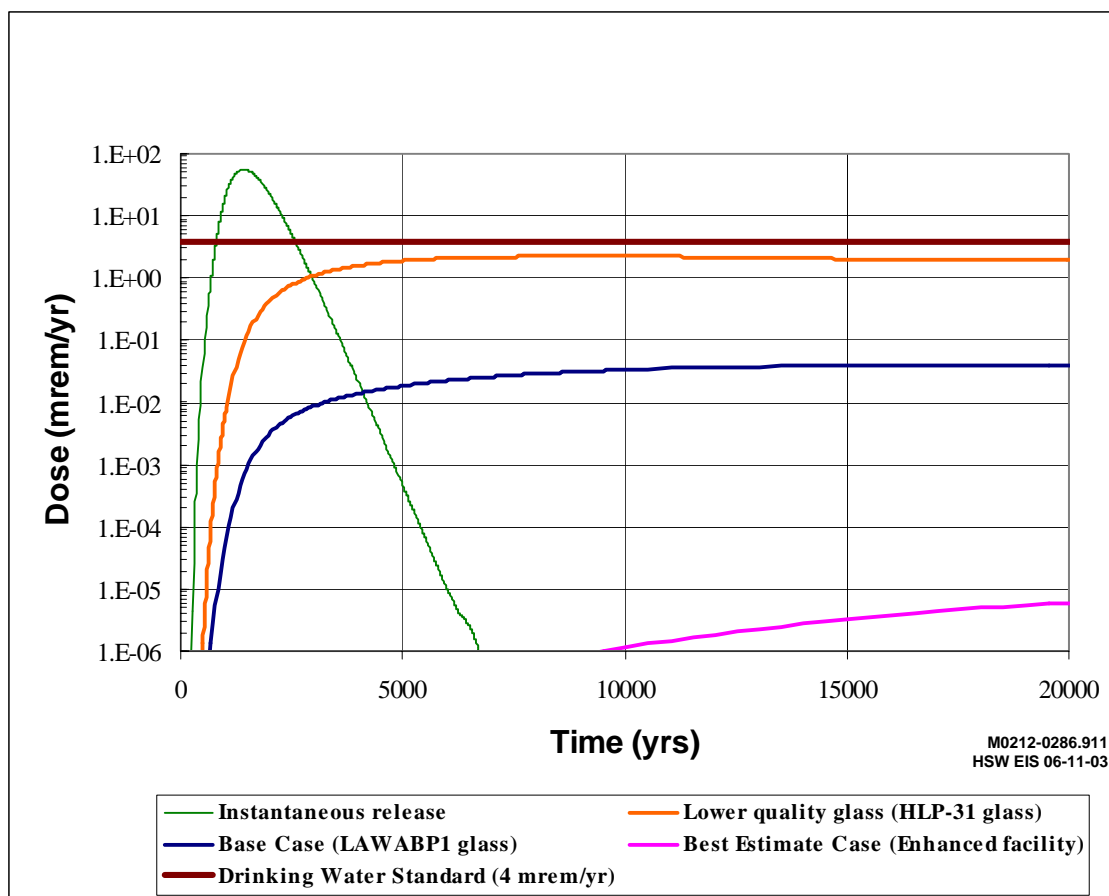


Figure G.95. Drinking Water Dose at a Well 100 Meters Downgradient from the ILAW Disposal Facility as a Function of Time for Various ILAW Waste Form Performance and Disposal Facility Parameters (after Mann et al. [2001])

Table G.40. Drinking Water Doses (mrem/yr) (after Mann et al. [2001])^(a)

Case	@ 1,000 Years	@ 10,000 Years	Peak (@)
Base Case (LAWABP1 glass) ^(b)	0.00007	0.034	0.040 (98,000 yrs)
Best Estimate Case (Enhanced Facility Design) ^(c)	--	0.000001	Not calculated
Lower Quality Glass Case (HLP-31 glass)	0.006	2.2	2.3 (9,000 yrs)
Extreme Release Case (pulse)	19.7	--	56 (1,400 yrs)

(a) Renormalized for increased Tc-99, due to removal from Tc-99 separations process from WTP.
 (b) "Base analysis case" of the 2001 ILAW PA.
 (c) "Best estimate case" of 2001 ILAW PA.

The conceptual designs for the ILAW disposal facility have been evolving with time. The basic design is a set of large, deep trenches in the ground, underlain by RCRA-compliant liners. The presence of a surface barrier has remained constant while the width, depth, thickness, and placement of the trenches on the disposal site have changed. An important feature of the current conceptual design is a capillary break that acts as a moisture diverter underneath the surface barrier. As the name implies, this feature, using natural materials, diverts most of the water around and away from the waste forms. This case is labeled the “best estimate” case in the 2001 ILAW PA and was shown in Figure G.95 and summarized in Table G.40 as the “Best Estimate Case (Enhanced Facility).”

Although a wide variety of sensitivity cases were run in the 2001 ILAW PA, the ones of most interest here are those addressing various waste form performance. The release of contaminants from a waste form can be quite complex, particularly for those waste forms containing large amounts of sodium waste (such as those containing tank waste). Cases were run to test the sensitivity of the results to models and data used. Cases were also run to determine the effect of various waste forms.

To determine the performance of a lower-quality glass, the 2001 ILAW PA investigated the behavior of HLP-31 glass. This glass releases contaminants at a rate of about 10 times faster than LAWABP1 and, moreover, does not exhibit the common trait of decreased release as the concentration of silic acid (a by-product of glass dissolution) increases. For the conditions expected in the ILAW disposal facility, these two effects combine to cause the estimated potential impacts from HLP-31 waste forms to be about a factor of 100 greater than the potential impacts from the LAWABP1 waste forms. However, as seen from Figure G.95 and in Table G.40, even this higher release is estimated to be below 4 mrem/year.

To investigate the performance of an extremely poor waste form, the 2001 ILAW PA investigated an extreme release case that assumed that all waste was released instantaneously. Because of the thickness of soil underlying the proposed ILAW disposal facility, the pulse broadens to the shape seen in Figure G.95 and summarized in Table G.40, which is actually quite broad (full width at one-tenth maximum of approximately 2,000 years). For such cases, where the time over which release occurs is shorter than the time to travel through the soil to reach groundwater, the plateau-shaped curves of glass are replaced by peaked curves. The estimated drinking water dose for this instantaneous case is greater than 4 mrem/yr.

G.3.2 Additional Planned Analyses of Waste Disposal System Performance

The DOE has announced its plans for an environmental impact statement on the retrieval, treatment, and disposal of the waste being managed in the high-level waste tank farms at the Hanford Site and closure of the 149 single-shell tanks and associated facilities in the HLW tank farms (68 FR 1052). The tanks contain both radioactive and chemically hazardous waste. That document will provide additional analyses of low-activity waste treatment alternatives and resulting impacts upon disposal system performance.

G.3.3 Specific Scaling of ILAW PA Results for Use in the Analysis

G.3.3.1 Scaling for Estimated Inventory

Under a number of alternatives (Alternative Groups A, C, D₁, and E₃) where ILAW disposal is sited near the PUREX facility, results of a sensitivity case in Mann et al. (2001) that analyzed the effect of 25,550 Ci of technetium was used. This case reflected no technetium removal in the separation processes from the Waste Treatment Plant. This technetium-99 inventory (25,550 Ci) is a factor of 4.4 higher than the estimated inventory of technetium-99 (about 5790 Ci) if technetium-99 removal were considered in the separation process. The resulting scaled technetium-99 concentrations and other constituents from the ILAW PA that were used for those alternative groups where ILAW disposal is sited near the PUREX Plant is provided in Figure G.96.

G.3.3.2 Scaling for Alternative HSW-EIS Disposal Site Locations

Potential impact results presented for the ILAW disposal facility were based on performance assessment calculations made for siting the facility in the vicinity of the PUREX Plant, as summarized by Mann et al. (2001). However, for a few of the alternative groups, the ILAW disposal facility is sited in areas south of the CWC and at ERDF, and the calculated potential impacts at these alternative sites would be expected to be different because of the change in hydrogeologic conditions and hydraulic properties at these three locations.

For purposes of this analysis, the potential human health impacts results presented in Appendix F and Section 5.11 for Alternative Group B (where the ILAW disposal facility is sited in an area south of the CWC) and Alternative Groups D₃, E₁, and E₂ (where the ILAW disposal facility is sited in the ERDF area) are based on simple scaling of comparative simulation results of source releases in these areas using the sitewide groundwater flow and transport model. Groundwater concentrations and results of potential human health impacts summarized in the original performance assessment calculations described in Mann et al. (2001) were based on well intercept factors (WIFs) or dilution factors from a given areal flux of a hypothetical contaminant released to the unconfined aquifer from the ILAW disposal facility (Bergeron and Wurstner 2000). The WIF is defined as the ratio of the concentration at a well location in the aquifer to the concentration of infiltrating water entering the aquifer. These WIFs are being used in conjunction with calculations of released contaminant fluxes through the vadose zone to estimate potential impacts from radiological and hazardous chemical contaminants within the ILAW disposal facility at LOAs.

For the purposes of implementing the unit-release calculation, the concentration of a source entering the aquifer of 1 Ci/m³ was used. The rate of mass flux associated with this concentration is a function of the infiltration rate assumed for the disposal facility covered by the Modified RCRA Subtitle C Barrier system. With a rate of 0.42 cm/yr assumed for the ILAW disposal facility, the resulting solute flux entering the aquifer from each of the disposal concepts is 4.2×10^{-3} Ci/yr/m². This is the product of the contaminant concentration in the infiltrating water and the infiltration rate.

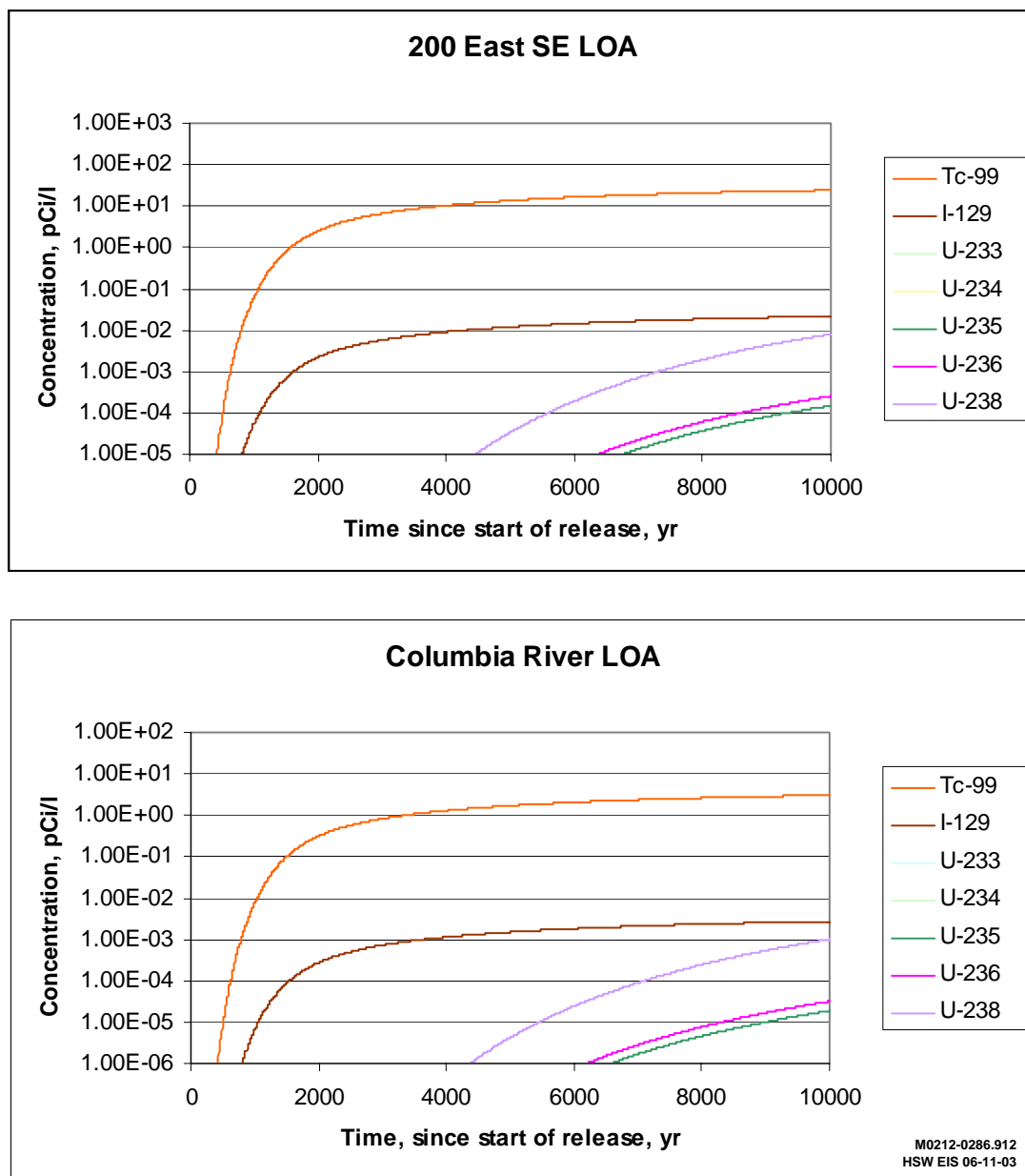


Figure G.96. Scaled Concentrations of Key Constituents that were Used from the ILAW PA at the 200 East Area SE and Columbia River LOAs for Those Alternative Groups where ILAW Disposal was Sited near the PUREX Plant, Alternative Groups A, C, D₁, and E₃

In the simulations used to support this assessment, the same calculation performed for the base case described in Bergeron and Wurstner (2000) (see Section 6.1.1 in Volume I of this EIS) using the regional scale model was performed again at the approximate PUREX location and the two alternative areas described in Alternative Group B (south of the CWC) and Alternative Groups D₃, E₁, and E₂ (near ERDF) using the groundwater models in this assessment. The ratio of predicted WIFs at the 1-km (0.6-mi) LOA

and along the Columbia River about 1 km downgradient from the CWC and ERDF locations to the comparable predicted WIFs from the PUREX locations provided the basis for the scaling of results used in this analysis.

The groundwater model using the extended basalt subcrop conditions north of the 200 East Area and the resultant predominant easterly flow out of the 200 East and West Areas was considered to be most representative of original conditions simulated with the model used by Bergeron and Wurstner (2000) of the two groundwater evaluations in this analysis. This model was the one used in this comparative analysis.

Results of applying WIFs using an assumed infiltration rate in the source area of 0.42 cm/yr for the three postulated ILAW disposal locations, as presented in Figure G.95, suggest that predicted groundwater concentrations and calculated human health impacts would be a factor of about 3 higher and about 3.4 higher at the 1-km (0.6-mi) LOA downgradient of the HSW disposal site locations (south of CWC and near ERDF, respectively) relative to a comparable location about 1 km downgradient from the PUREX location. These higher-predicted concentrations would be consistent with differences in hydrogeology at these two locations relative to conditions found near the PUREX Plant. Near the PUREX Plant, the upper part of the unconfined aquifer is largely composed of very permeable sediments associated with the Hanford formation. Whereas, at the ERDF and CWC locations, the upper part of the unconfined aquifer is made up of less permeable sand and gravel sediments associated with the Ringold sediments.

Results of applying WIF ratios at LOAs along the Columbia River resulting from releases at these two alternative locations are also presented in Table G.41. The resulting WIF ratio suggests that peak concentrations estimated along the Columbia River from these alternative locations of disposal would have about a factor of 0.8 and 0.9 lower, respectively, than was calculated from releases near the PUREX Plant. The reduction in concentration levels would be consistent with the longer flow path to the Columbia River location.

Table G.41. Well Intercept Factors at LOAs Downgradient from the ILAW Disposal Facility Sited Near the PUREX Plant and Alternative Locations

	Near PUREX	South of CWC	Near ERDF
1-km LOA			
PUREX WIF	5.1E-04	1.5E-03	1.8E-03
WIF Ratio (near PUREX)	1.0	3.0	3.4
Columbia River LOA			
PUREX Ratio	1.8E-04	1.4E-04	1.6E-04
WIF Ratio (near PUREX)	1.0	0.8	0.9

G.4 Effect of Changing Assumptions on Long-Term Cover System Performance

The section presents results from a selected set of sensitivity cases that were evaluated to examine and illustrate the effect of changing assumptions related to cover system performance on predicted groundwater quality impacts. The cases evaluated were related to groundwater impacts from selected wastes categories and configurations proposed under Alternative Group D₁. Two specific assumptions evaluated were as follows:

- No cover is assumed to exist and waste release is controlled by infiltration through natural vegetated surface conditions likely would persist following site closure. The assumed infiltration rate for these conditions is 0.5 cm/yr.
- The RCRA Subtitle C Barrier system is assumed to persist for the entire period of analysis and waste release is assumed to be controlled by the cover design infiltration rate of 0.01 cm/yr.

The specific contaminants and waste categories evaluated in these sensitivity cases included ungrouted Upper Bound inventories of technetium-99 and iodine-129 contained in MLLW and ungrouted and grouted Upper Bound inventories of uranium-238 contained in MLLW (see Figures G.97 and G.98). These specific examples illustrate the effect of the cover assumptions for contaminants from Mobility Class 1 ($K_d = 0.0$ mL/g) and Mobility Class 2 ($K_d = 0.6$ mL/g).

A comparison of results based on the current conservative cover system assumption of failure after 500 years and a return to natural infiltration within 500 years after failure produces very similar potential impacts to those predicted with the assumption that no-cover system is used. For all cases examined, differences in the results show predicted peak concentrations at the 1-km LOA, based on the 500-year cover system assumption, to be slightly lower and to arrive about 600 to 700 years later than the calculated peak concentrations at the 1-km LOA for the no-cover assumption. The delay in arrival time is reflective of the effect of the lower infiltration and release rate that would be expected to occur when the cover system is assumed to operate at or near its design infiltration of 0.01 cm/yr for the first 600 to 700 years after closure.

Figures G.97 and G.98 also compare resulting potential impacts using a calculational assumption where the cover system remains intact and does not fail during the period of interest. For all cases examined, predicted peak concentrations at the 1 km LOA consistent with the intact cover system assumption are calculated to be about 7 percent of the peak and to arrive over a much longer period of time than the peak concentration arrival time at the 1-km LOA for the 500-year cover scenario (see Table 5.13 in Section 5.3 of Volume I of this EIS). Results based on this assumption reflect the effect of the expected reduced infiltration and waste release from the waste disposal zone while the cover system is assumed to be intact and operating at its design infiltration rate of 0.01 cm/yr.

G.5 Potential Groundwater Quality Impacts at Low-Level Waste Management Area Boundaries for Selected Alternatives

This primary comparative assessment used lines of analysis located on the Hanford Site along lines approximately 1 km (0.6 mi) downgradient of aggregate Hanford solid waste (HSW) disposal areas within the 200 East and 200 West Areas, at ERDF, and near the Columbia River located about 100 meters downgradient from all disposal site areas (see Figure G.1). The HSW disposal facilities are not contiguous units and therefore a facility boundary compliance analysis that may be appropriate on a trench-by-trench basis would not lend itself to a comparison of the alternative groups presented in this EIS. However, additional analyses of potential groundwater quality impacts for the new Combined-Use Facility in this HSW EIS (Alternative Groups D₁, D₂, and D₃), are presented in this section and provide a perspective on the relative potential impact at waste management boundaries immediately 100 meters downgradient of the aggregate waste disposal area versus potential impacts at the 1-km LOAs. A similar impact analysis also is provided for all LLW and MLLW disposed of before 2008 considered in this analysis for another perspective.

Because of assumptions used in waste release, vadose zone transport, and introduction of constituent release to underlying groundwater, these analyses represent a very conservative evaluation, that is, an overestimate of potential water quality impacts in the vicinity of aggregate low-level waste management area (LLWMA) boundaries and should not be considered a compliance analysis as required by DOE Order 435.1 (DOE 2001), RCRA closure, or CERCLA. The conservatism used in this analysis is particularly evident in the analysis of waste contained in LLBG 218-E-12B, where the aquifer system is predicted to become dry over the period of interest (see Section G.5.2). Specific unit releases used to approximate potential impacts from waste categories and associated disposal areas were represented as a linear source just inside the aquifer system down-slope relative to the top of the basalt bedrock underlying this LLBG. This representation is a simplistic representation of the complex future migration of contaminants from this burial ground and resulting concentration levels estimated downgradient of LLWMA 2 likely would be substantially less than those reported here.

With respect to conservatism in the broader comparative analysis (1-km LOAs) presented in the previous section, the maximum concentrations presented for each 1-km LOA and alternative group reflected a summation of predicted maximum concentrations for several waste categories regardless of their position on the LOA. These resulting concentrations also were used to provide a determination of the sum-of-fractions of benchmark MCLs for key constituents (that is, technetium-99 and iodine-129) for each alternative group and are presented in Section 3.4 and the Summary of this HSW EIS. That approach, that is, combining groundwater concentrations from separate waste sources, would not be appropriate for results of analyses presented in this section because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category.

A discussion and summary of ratios to benchmark MCLs for technetium-99 and iodine-129 for each waste category in the three alternatives groups (D₁, D₂, and D₃) are presented in Section G.5.4.4.

G.5.1 Local-Scale Lines of Analysis

Lines of analysis used in these local-scale calculations were positioned to be within about 100 meters of the aggregate waste management areas, as shown in Figures G.99 and G.100. In the 200 East Area, the LOAs were about 100 meters downgradient from LLWMAs 1 and 2 and a designated integrated disposal area near the PUREX Plant. In the 200 West Area, the LOAs were about 100 meters downgradient from aggregate LLWMAs 3 and 4. At ERDF, the LOAs were about 100 meters downgradient from the designated integrated disposal area hypothetically located within the third cell of ERDF.

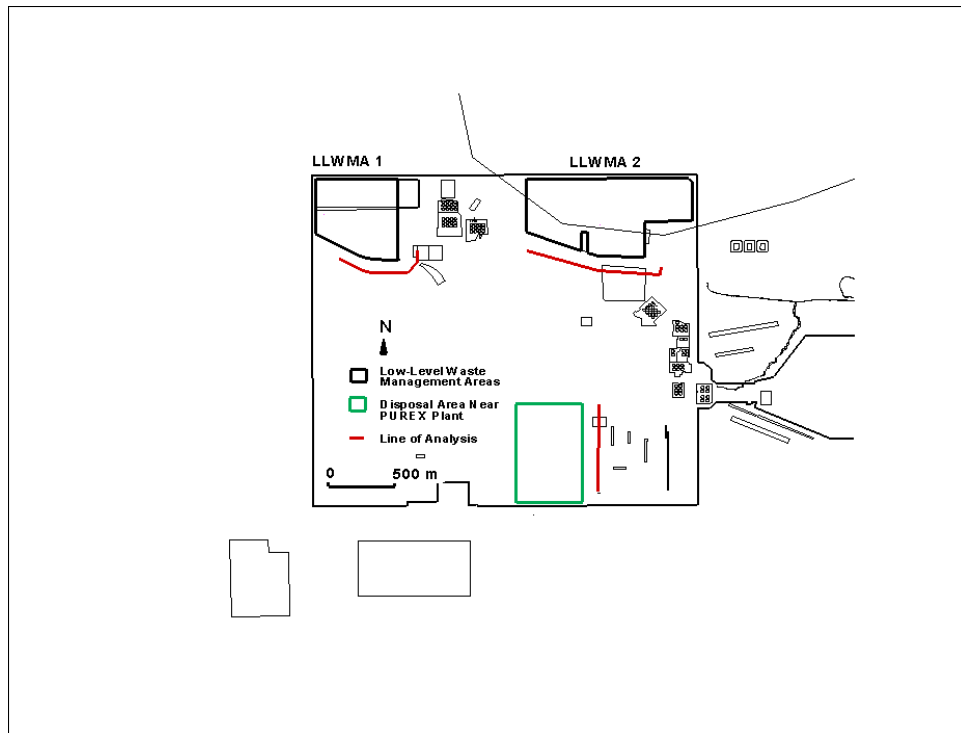


Figure G.99. Local-Scale Lines of Analysis 100 Meters Downgradient from the LLW Management Areas in the 200 East Area

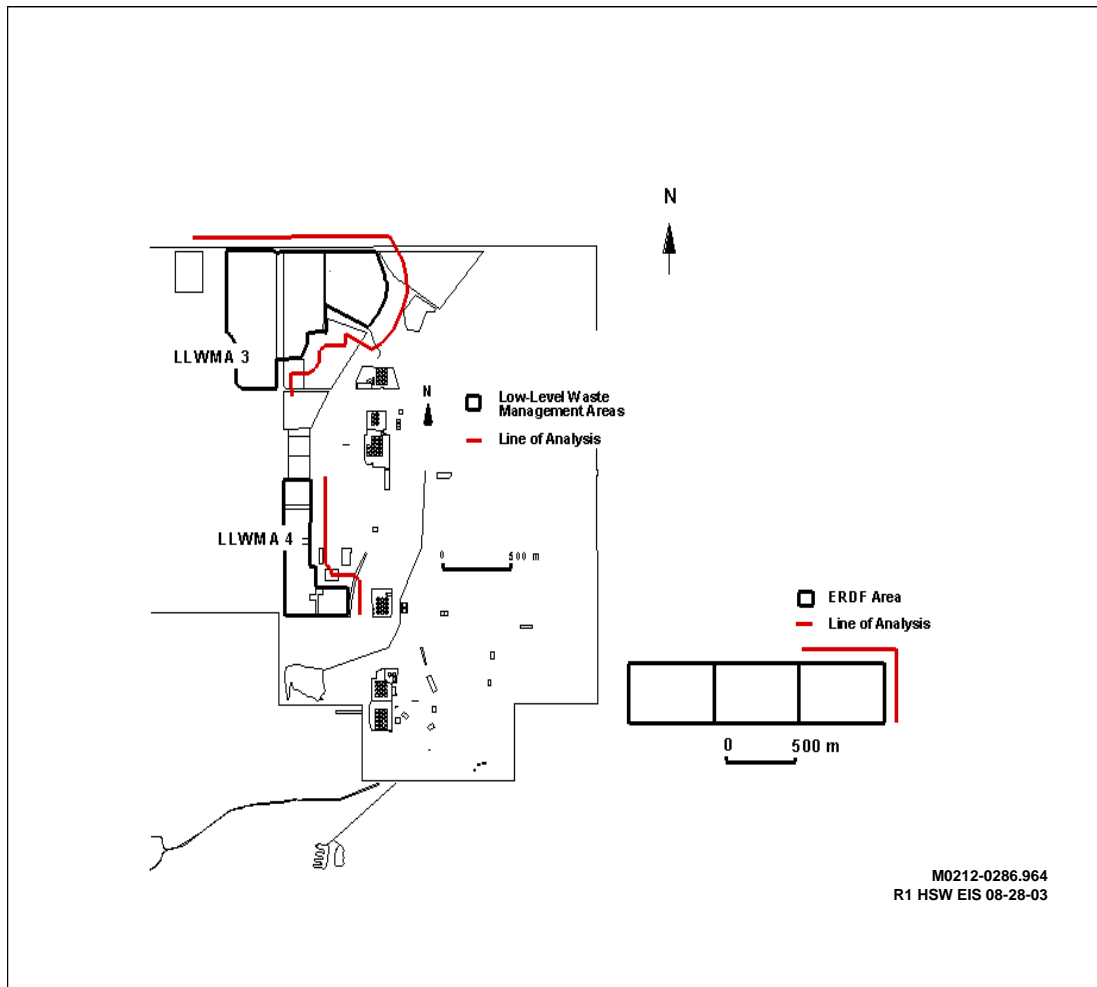


Figure G.100. Local-Scale Lines of Analysis 100 Meters Downgradient from the LLW Management Areas in the 200 West Area and at ERDF

G.5.2 Source-Term Release and Vadose Zone Transport

The potential groundwater quality impacts associated with the following local-scale analysis for Alternative Groups D₁, D₂, and D₃ were based on the same source-term release and vadose transport calculations for these alternative groups in the main comparative analysis described in Sections G.1.3 and G.1.4.

G.5.3 Unit-Release Calculations and Transport in Groundwater

This analysis made use of the unit-release concept described previously in Section G.1.5. Three separate local-scale models of the Hanford sitewide groundwater model developed for the 200 East Area, 200 West Area, and at ERDF (Figures G.101, G.102, and G.103, respectively) were used in the analysis. The distributions of hydraulic characteristics and geometry of major hydrogeologic units used in the

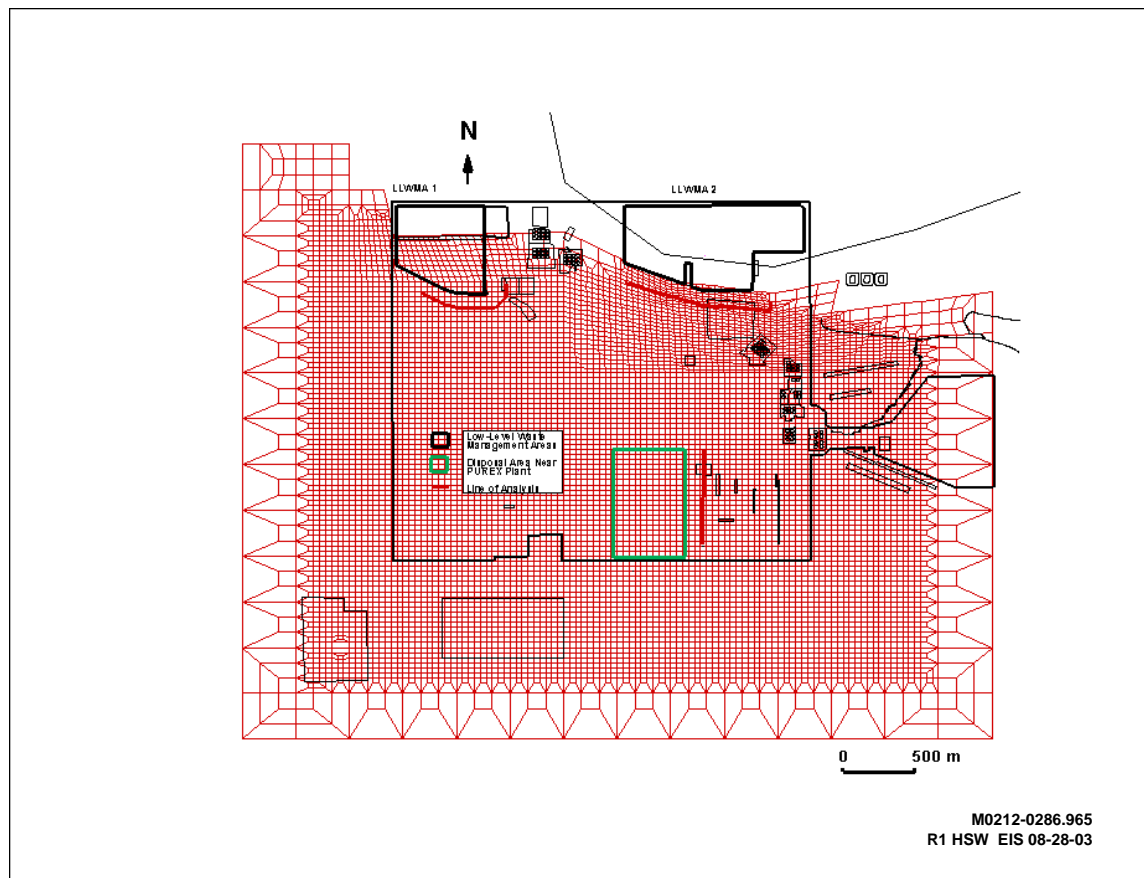


Figure G.101. Local-Scale Finite Element Grid Used in the Unit-Release Calculations in Groundwater Beneath the 200 East Area

local-scale models were based on the interpolation of regional-scale model characteristics and interpretation of major units onto the local-scale model grids. As was done for the regional-scale transport simulations, calculations were performed for post-Hanford conditions, as described in Section G.1.5.

For this analysis, a longitudinal dispersivity, D_L , of 10 m (33 ft) was selected using this typical approach for estimating longitudinal dispersivity based on the scale of interest. The key scale of interest is the minimum distance between some of the source areas within the aggregate waste management areas to within about 100 meters downgradient from the waste management boundaries. Thus, a dispersivity value used in the analysis was selected to be approximately equal to 10 percent of the minimum travel distance of interest of about 100 meters. A transverse dispersivity of about 20 percent of the longitudinal dispersivity, or 2 m, also was used in the analysis.

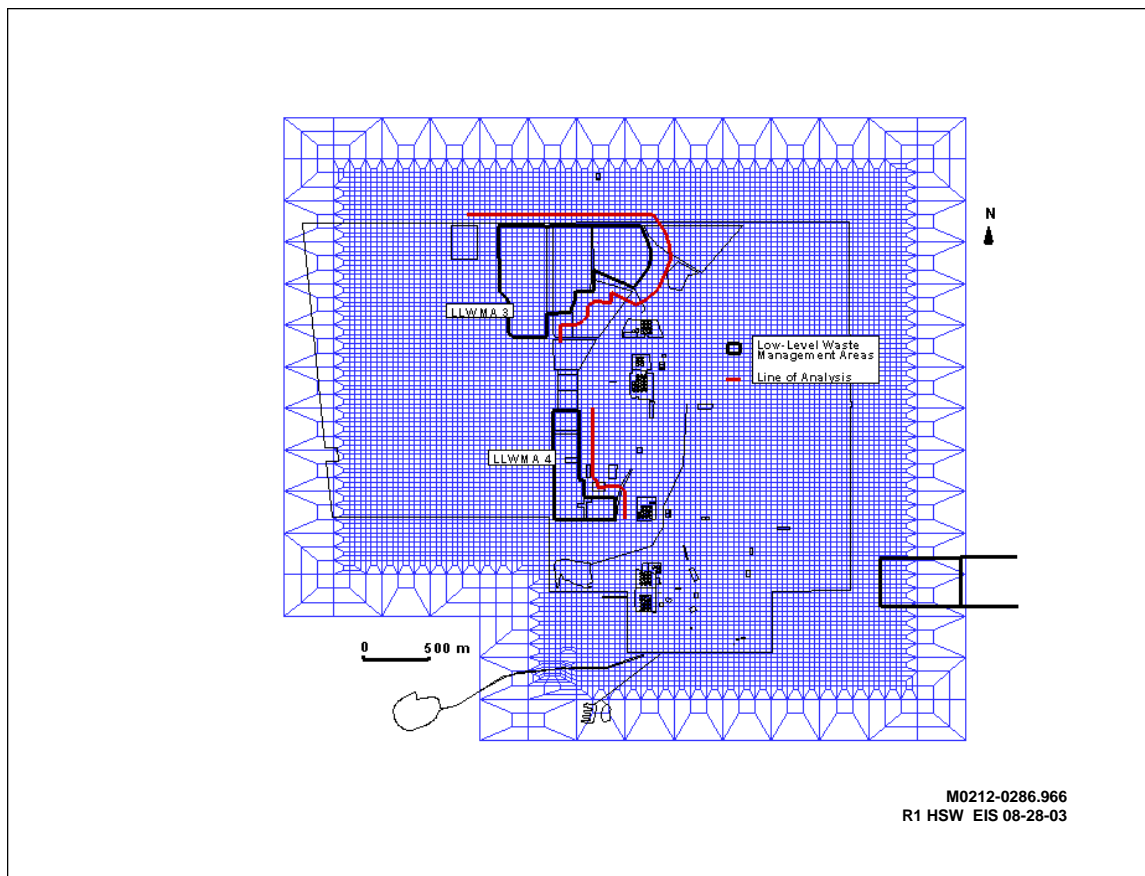


Figure G.102. Local-Scale Finite Element Grid Used in Unit-Release Calculations in Groundwater Beneath the 200 West Area

Because the aquifer system is predicted to be dry beneath parts of the LLBGs in the 200 East Area, the specific unit-release calculations used to represent waste categories and associated disposal areas located within LLBG 218-E-12B was represented as a line source just inside the aquifer system down-dip (relative to the top of the underlying basalt bedrock) of this LLBG. This representation is a simplified representation of the complex future migration of contaminants from this burial ground and resulting concentration levels estimated about 100 meters downgradient from LLWMA 2 are deemed to be very conservative.

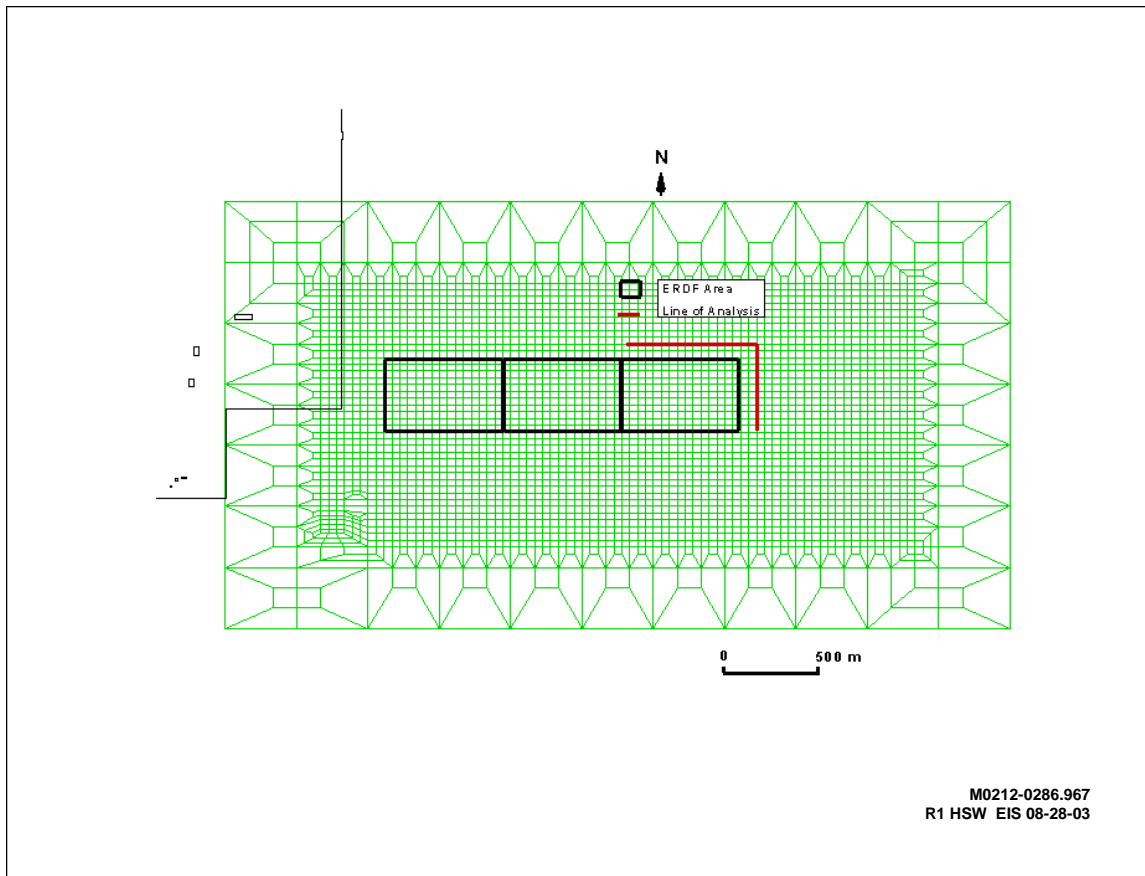
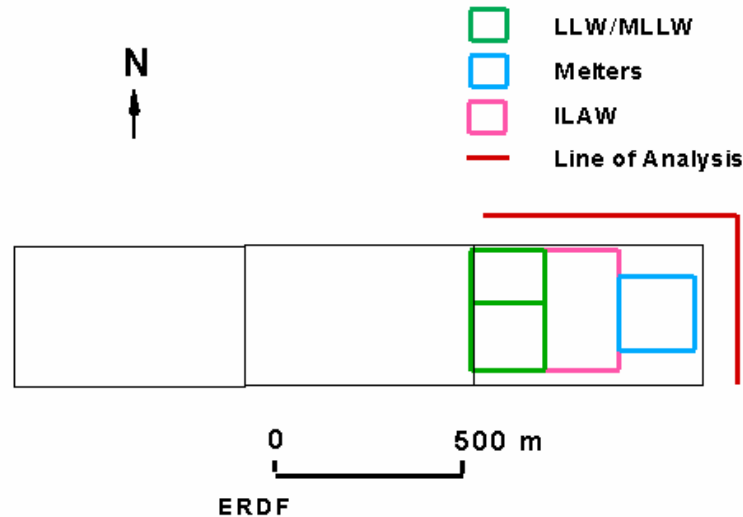


Figure G.103. Local-Scale Finite Element Grid Used in Unit-Release Calculations in Groundwater Beneath ERDF

This evaluation was done by first calculating transport of 10-year releases of a unit of dry mass into the unconfined aquifer at the approximate locations of the LLBGs at the water table. These transport calculations were made with local-scale versions of the steady-state groundwater flow field developed with the regional-scale model. These calculated concentrations, based on a unit release, were then used in the convolution integral calculational method to translate transport of mass releases from the LLW through the vadose zone and the aquifer to LOAs downgradient from designated aggregate LLWMAs.

The approximate disposal area configurations used in the unit-release calculations for each waste category for waste disposed of before 2008 for the 200 East and 200 West Areas for all three alternative groups (D_1 , D_2 , and D_3) combined are shown in Figures G.104 (200 East Area) and G.105 (200 West Area). The approximate disposal area configurations used in the unit-release calculations for each waste category for waste disposed of after 2007 for all three alternative groups (D_1 , D_2 , and D_3) are shown in Figures G.106, G.107, and G.108, respectively.



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Figure G.108. Approximate Disposal Area Footprint used in Alternative Group D₃ (at ERDF) to Represent Waste Disposed of After 2007 in the Unit-Release Calculation in Groundwater

Similar to what was done in the 1-km LOA calculations, potential results calculated for the ILAW disposal facility at various LLWMA boundaries for each alternative were based on performance assessment calculations made for siting the facility in the vicinity of the PUREX Plant, as summarized by Mann et al. (2001). The predicted concentrations for the constituents of interest at the near PUREX location boundary are approximately 40 percent higher than concentrations estimated at 1 km (see Figure G.96) as estimated by Mann et al. (2001). For purposes of this analysis, estimated concentrations of key constituents and associated potential human health impacts results at the ERDF and 218-E-12B LLBG were scaled off of the ratio of the estimated concentrations for technetium-99 in LLW at the PUREX location using the local-scale models to comparative concentrations at the ERDF and 218-E-12B using the other local-scale models. Based on these specific concentration ratios, estimated concentrations of all constituents released from the ILAW at the ERDF and the 218-E-12B LLBG were estimated to be about 4 times those estimated by Mann et al. (2001) at the near PUREX Plant location.

G.5.4 Summary of Results

Potential impacts on groundwater for Alternative Group D₁, D₂, and D₃ within about 100 meters of the aggregate waste management areas are provided in the following sections. The alternatives, waste types, and disposal conditions are briefly stated to establish the framework for comparing the results. Results for this alternative group for waste disposed of before 2008 are summarized in Table G.42. Results for waste disposed of after 2007 for Alternative Groups D₁, D₂, and D₃ are summarized in Tables G.43, G.44, and G.45, respectively.

Table G.45. Predicted Peak Concentrations of Key Constituents for Wastes Disposed of After 2007 at Aggregate LLW Management Area Boundaries, Alternative Group D₃

Constituent	Benchmark MCL (pCi/L)	Hanford Only Volume			Lower Bound Volume			Upper Bound Volume		
		Inventory (Ci)	Maximum Concen- tration Within 10,000 yrs (pCi/L)	Approx. Peak Arrival Time (yrs)	Inventory (Ci)	Maximum Concentration Within 10,000 yrs (pCi/L)	Approx. Peak Arrival Time (yrs)	Inventory (Ci)	Maximum Concen- tration Within 10,000 yrs (pCi/L)	Approx. Peak Arrival Time (yrs)
Projected Cat 1 LLW After 2007										
ERDF Area										
C-14	2,000	1.28E+01	0.00E+00	>10,000	1.56E+01	0.00E+00	>10,000	1.59E+01	0.00E+00	>10,000
Tc-99	900	1.08E+00	2.91E+01	1660	1.32E+00	3.55E+01	1660	1.33E+00	2.83E+01	1660
Grouted Tc-99	900									
I-129	1	3.01E-03	8.10E-02	1660	3.67E-03	9.88E-02	1660	3.67E-03	7.81E-02	1660
Grouted I-129	1									
U-233	(a)	3.71E-01	0.00E+00	>10,000	4.52E-01	0.00E+00	>10,000	4.52E-01	0.00E+00	>10,000
U-234	(a)	6.13E-01	0.00E+00	>10,000	7.47E-01	0.00E+00	>10,000	9.21E-01	0.00E+00	>10,000
U-235	(a)	1.29E-01	0.00E+00	>10,000	1.57E-01	0.00E+00	>10,000	1.68E-01	0.00E+00	>10,000
U-236	(a)	1.46E-02	0.00E+00	>10,000	1.78E-02	0.00E+00	>10,000	1.78E-02	0.00E+00	>10,000
U-238	(a)	1.47E+00	0.00E+00	>10,000	1.79E+00	0.00E+00	>10,000	2.08E+00	0.00E+00	>10,000
Projected Cat 3 LLW After 2007										
ERDF Area										
C-14	2,000	4.44E-01	0.00E+00	>10,000	4.62E-01	0.00E+00	>10,000	1.45E+02	0.00E+00	>10,000
Tc-99	900									
Grouted Tc-99	900	3.23E+03	7.32E+02	990	3.23E+03	7.32E+02	990	3.23E+03	5.78E+02	990
I-129	1	1.96E-06	5.27E-05	1670	2.04E-06	5.49E-05	1670	2.04E-06	4.34E-05	1670
Grouted I-129	1	5.00E+00	3.59E-01	990	5.00E+00	3.59E-01	990	5.00E+00	2.83E-01	990
U-233	(a)	2.98E-01	0.00E+00	>10,000	3.10E-01	0.00E+00	>10,000	1.80E-01	0.00E+00	>10,000
U-234	(a)	3.73E+02	0.00E+00	>10,000	3.89E+02	0.00E+00	>10,000	3.11E+02	0.00E+00	>10,000
U-235	(a)	1.07E+01	0.00E+00	>10,000	1.11E+01	0.00E+00	>10,000	1.20E+01	0.00E+00	>10,000
U-236	(a)	4.82E+01	0.00E+00	>10,000	5.02E+01	0.00E+00	>10,000	2.89E+01	0.00E+00	>10,000
U-238	(a)	5.99E+02	0.00E+00	>10,000	6.24E+02	0.00E+00	>10,000	5.04E+02	0.00E+00	>10,000
Projected MLLW After 2007										
ERDF Area										
C-14	2,000	1.46E+00	0.00E+00	>10,000	1.46E+00	0.00E+00	>10,000	1.45E+00	0.00E+00	>10,000
Tc-99	900	8.34E+00	2.25E+02	1660	8.36E+00	2.25E+02	1660	8.27E+00	1.76E+02	1660
Grouted Tc-99	900									
I-129	1	3.50E-02	9.43E-01	1660	3.51E-02	9.45E-01	1660	3.48E-02	7.41E-01	1660
Grouted I-129	1									
U-233	(a)	4.67E-03	0.00E+00	>10,000	4.68E-03	0.00E+00	>10,000	4.64E-03	0.00E+00	>10,000
U-234	(a)	5.44E+00	0.00E+00	>10,000	5.45E+00	0.00E+00	>10,000	5.40E+00	0.00E+00	>10,000
U-235	(a)	8.67E-02	0.00E+00	>10,000	8.69E-02	0.00E+00	>10,000	8.61E-02	0.00E+00	>10,000
U-236	(a)	1.02E-01	0.00E+00	>10,000	1.02E-01	0.00E+00	>10,000	1.01E-01	0.00E+00	>10,000
U-238	(a)	1.36E+00	0.00E+00	>10,000	1.36E+00	0.00E+00	>10,000	1.35E+00	0.00E+00	>10,000
Projected Grouted MLLW After 2007										
200 East Area										
C-14	2,000	2.86E+00	0.00E+00	>10,000	2.87E+00	0.00E+00	>10,000	4.25E+00	0.00E+00	>10,000
Tc-99	900									
Grouted Tc-99	900	1.57E+02	3.55E+01	990	1.57E+02	3.61E+01	990	3.34E+02	5.98E+01	990
I-129	1									
Grouted I-129	1	6.87E-02	4.93E-03	990	6.88E-02	4.91E-03	990	7.06E-02	4.00E-03	990
U-233	(a)	8.91E-03	0.0E+00	>10,000	8.93E-03	0.00E+00	>10,000	9.20E-03	0.00E+00	>10,000
U-234	(a)	1.07E+01	0.0E+00	>10,000	1.07E+01	0.00E+00	>10,000	3.35E+02	0.00E+00	>10,000
U-235	(a)	1.70E-01	0.0E+00	>10,000	1.70E-01	0.00E+00	>10,000	1.47E+01	0.00E+00	>10,000

Table G.45 (contd)

Constituent	Benchmark MCL (pCi/L)	Hanford Only Volume			Lower Bound Volume			Upper Bound Volume		
		Inventory (Ci)	Maximum Concen- tration Within 10,000 yrs (pCi/L)	Approx. Peak Arrival Time (yrs)	Inventory (Ci)	Maximum Concentration Within 10,000 yrs (pCi/L)	Approx. Peak Arrival Time (yrs)	Inventory (Ci)	Maximum Concen- tration Within 10,000 yrs (pCi/L)	Approx. Peak Arrival Time (yrs)
U-236	(a)	2.00E-01	0.00E+00	>10,000	2.00E-01	0.00E+00	>10,000	2.05E-01	0.00E+00	>10,000
U-238	(a)	2.64E+00	0.00E+00	>10,000	2.65E+00	0.00E+00	>10,000	3.42E+02	0.00E+00	>10,000
Projected Melter Waste										
ERDF Area										
C-14	2,000									
Tc-99	900									
Grouted Tc-99	900	3.89E+01	9.06E+00	990	3.89E+01	9.06E+00	990	3.89E+01	9.06E+00	990
I-129	1									
Grouted I-129	1									
U-233	(a)	8.49E-01	0.00E+00	>10,000	8.49E-01	0.00E+00	>10,000	8.49E-01	0.00E+00	>10,000
U-234	(a)	4.60E-01	0.00E+00	>10,000	4.60E-01	0.00E+00	>10,000	4.60E-01	0.00E+00	>10,000
U-235	(a)	1.90E-02	0.00E+00	>10,000	1.90E-02	0.00E+00	>10,000	1.90E-02	0.00E+00	>10,000
U-236	(a)	1.70E-02	0.00E+00	>10,000	1.70E-02	0.00E+00	>10,000	1.70E-02	0.00E+00	>10,000
U-238	(a)	4.10E-01	0.00E+00	>10,000	4.10E-01	0.00E+00	>10,000	4.10E-01	0.00E+00	>10,000
(a) The benchmark MCL for uranium is 30 µg/L expressed as total uranium. To convert isotope specific concentrations from pCi/L to µg/L, use following conversion factors:										
<ul style="list-style-type: none"> • Uranium-233 - 1.05E-04 • Uranium-234 - 1.62E-04 • Uranium-235 - 4.66E-01 • Uranium-236 - 1.58E-02 • Uranium-238 - 3.00E+00. 										

G.5.4.1 Alternative Group D₁

LLW considered in Alternative Group D₁ includes the same wastes considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW and MLLW in a single, lined, modular combined-use facility near the PUREX Plant after 2007. The melter trench and ILAW disposal facility would be placed in the same general area.

G.5.4.1.1 Wastes Disposed of Before 2008

Waste disposed of before 2008 consists of four categories: 1) pre-1970 LLW, 2) 1970–87 LLW, 3) 1988–95 LLW, and 4) 1996–2007 LLW and MLLW. Following are brief summaries of potential groundwater quality impacts at about 100 meters downgradient from aggregate LLWMAs for each of these waste categories. Results for waste disposed of before 2008 for Alternative Group D₁ were presented in Table G.42.

Pre-1970 Low-Level Waste

Pre-1970 waste is primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area and in LLBG 218-W-4C (LLWMA 4) in the 200 West Area. For these wastes, technetium-99 and iodine-129 released from LLBGs have the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 80 percent of the benchmark MCL and technetium-99 about 30 percent of the benchmark MCL about 100 meters downgradient of LLWMA 2 in the 200 East Area. These resulting concentration levels estimated about 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Section G.5.3)

1970–1987 Low-Level Waste

1970–1987 waste is primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area and in LLBG 218-W-4A (LLWMA 4), 218-W-3A, and 218-W-3AE (LLWMA 3) in the 200 West Area. Iodine-129 released from 1970–1987 waste from LLBGs has the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 7 times higher than the benchmark MCL of 1 pCi/L about 100 meters downgradient of LLWMA 2 in the 200 East Area. As in the case of pre-1970 LLW, these resulting concentration levels estimated about about 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Section G.5.3).

1988–1995 Low-Level Waste

1988–1995 waste is primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area and in LLBG 218-W-3A and 218-W-5 (LLWMA 4) in the 200 West Area. Technetium-99 and iodine-129 released from 1988–1995 waste from LLBGs have the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 5 percent of the benchmark MCL about 100 meters downgradient of LLWMA 2 in the 200 East Area. Technetium-99 is estimated to be about 7 percent of the benchmark MCL about 100 meters downgradient of LLWMA 2 in the 200 East Area and about 9 percent of the benchmark MCL about 100 meters downgradient of LLWMA 3 in the 200 West Area.

As in the case of pre-1970 LLW, concentration levels estimated about 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Section G.5.3).

1996–2007 LLW and MLLW

1996–2007 waste is disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area and in LLBG 218-W-3A and 218-W-5 (LLWMA 3) in the 200 West Area. Following is a brief summary of potential groundwater quality impacts from the three main components of these wastes, including 1) Category 1 LLW, 2) Category 3 LLW, and 3) MLLW.

Category 1 LLW. Iodine-129 and technetium-99 released from 1996–2007 Cat 1 LLW primarily located in LLBG 218-W-5 have the highest potential impact on groundwater quality. Iodine-129 levels are estimated to be about 15 to 18 percent of the benchmark MCL about 100 meters downgradient of LLWMA 3 in the 200 West Area for the Hanford Only and Upper Bound waste volumes. Technetium-99 levels are estimated to be about 1 and 2 percent of the benchmark MCL about 100 meters downgradient of LLWMA 3 in the 200 West Area.

Category 3 LLW. Technetium-99 released from 1996–2007 Cat 3 LLW primarily located in LLBG 218-W-5 has the highest potential impact on groundwater quality. Technetium-99 levels are estimated to be about 2 percent of the benchmark MCL about 100 meters downgradient of LLWMA 3 in the 200 West Area.

MLLW. Technetium-99 and iodine-129 released from ungrouted 1996–2007 MLLW have the highest potential impact on groundwater quality. Concentration levels of all constituents are below benchmark MCLs for grouted 1996-2007 MLLW.

Estimated technetium-99 concentration levels are about 21 percent of the benchmark MCL about 100 meters downgradient of LLWMA 3 for all volumes. Estimated iodine-129 concentration levels are about 48 and 80 percent of the benchmark MCL about 100 meters downgradient of LLWMA 3 for the Hanford Only and Upper Bound waste volumes and about equal to the benchmark standard about 100 meters downgradient of WMA 2 for the Upper Bound waste volume.

As in the case of pre-1970 LLW, concentration levels estimated about 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Section G.5.3).

G.5.4.1.2 Waste Disposed of After 2007 Near the PUREX Plant

The highest potential impact for this alternative group reflects the emplacement of all wastes disposed of after 2007 in the vicinity of the PUREX Plant. Potential impacts from LLW and MLLW are dominated by technetium-99 and iodine-129 (see Table G.43).

The maximum potential impact from technetium-99 is from Cat 3 LLW, where estimated concentration levels are about 21 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The maximum potential impact from iodine-129 is from ungrouted MLLW, where estimated concentration levels are about 29 and 26 percent of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively.

Estimated concentration levels of all other constituents in these waste categories and all constituents in other waste categories are well below benchmark MCLs.

G.5.4.2 Alternative Group D₂

LLW considered in Alternative Group D₂ includes the same wastes considered in Alternative Group D₁ but disposes of Cat 1 and Cat 3 LLW and MLLW in a single, lined, modular combined-use facility after 2007 in LLBG 218-E-12B. The melter trench and the ILAW disposal facility would be placed in the same general area.

G.5.4.2.1 Wastes Disposed of Before 2008

Because of assumptions in the source-term release and vadose zone modeling used for LLW previously disposed of before 2008 for Alternative D₂, results for this alternative group were the same for those waste categories calculated for Alternative Group D₁. Results for waste disposed of before 2008 for Alternative Group D₁ were presented in Table G.42.

G.5.4.2.2 Waste Disposed of After 2007 in the LLBG 218-E-12B

The highest potential impact for this alternative group reflects the emplacement of all wastes disposed of after 2007 in the LLBG 218-E-12B. Potential impacts from LLW and MLLW are dominated by technetium-99 and iodine-129 (see Table G.44).

The maximum potential impact from technetium-99 is from Cat 3 LLW, where estimated concentration levels are about 86 percent of the benchmark MCL for all waste volumes. The maximum potential impact from iodine-129 is from ungrouted MLLW, where estimated concentration levels are about 94 and 95 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The potential impact from iodine-129 is from Cat 3 LLW, where estimated concentration levels are about 38 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. These higher levels of potential groundwater quality impacts relative to those calculated for similar waste inventories in Alternative Group D₁ reflect differences in aquifer conditions found beneath the near-PUREX location (that is, high permeability and moderate saturated thickness of the Hanford formation at the water table) and the 218-E-12B LLBG (that is, slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table).

Estimate concentrations of all other constituents in these waste categories and all constituents in other waste categories are below benchmark MCLs.

As in the case of other wastes disposed of in LLBG 218-E-12B, these resulting concentration levels estimated about 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Section G.5.3)

G.5.4.3 Alternative Group D₃

LLW considered in Alternative Group D₃ includes the same wastes considered in Alternative Group D₁ but disposes of Cat 1 and Cat 3 LLW and MLLW in a single, lined, modular combined-use facility at ERDF after 2007. The melter trench and the ILAW disposal facility would also be placed at ERDF.

G.5.4.3.1 Wastes Disposed of Before 2008

Because of assumptions in the source-term release and vadose zone modeling used for LLW previously disposed of before 2008 for Alternative D₃, results for this alternative group were the same for those waste categories calculated for Alternative Group D₁. Results for waste disposed of before 2008 for Alternative Group D₁ were presented in Table G.42.

G.5.4.3.2 Waste Disposed of After 2007

The highest potential impact for this alternative group reflects the emplacement of all wastes disposed of after 2007 in LLBG 218-E-12B. Potential impacts from LLW and MLLW are dominated by technetium-99 and iodine-129 (see Table G.45).

The maximum potential impact from technetium-99 is from Cat 3 LLW, where estimated concentration levels are about 86 percent of the benchmark MCL for all waste volumes. The maximum potential impact from iodine-129 is from ungrouted MLLW, where estimated concentration levels are about 94 and 95 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The potential impact from iodine-129 is from Cat 3 LLW, where estimated concentration levels are about 38 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. These higher levels of potential groundwater quality impacts relative to those calculated for similar waste inventories in Alternative Group D₁ reflect differences in aquifer conditions found beneath the near PUREX location (that is, high permeability and moderate saturated thickness of the Hanford formation at the water table) and the 218-E-12B LLBG (that is, slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table).

Estimate concentrations of all other constituents in these waste categories and all constituents in other waste categories are below benchmark MCLs.

As in the case of other wastes disposed of in LLBG 218-E-12B, the resulting concentration levels estimated about 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Section G.5.3).

G.5.4.4 Summary of Ratios to Benchmark MCLs for Technetium-99 and Iodine-129

This section presents a discussion of the combined ratios of maximum potential concentrations to benchmark MCLs for technetium-99 and iodine-129 using the sum-of-fractions rule for all wastes

considered in the three alternative groups. The breakdown is provided in two broad categories—1) waste disposed of before 2008 and 2) waste disposed of after 2007—and includes results for the Hanford Only and Upper Bound waste volumes.

In general, the ratio of concentrations at the LLWMA boundary locations to concentrations at the 1-km locations ranged from 1.3:1 for wastes disposed of after 2007 at the combined-use facility located near the PUREX Plant to 22:1 for previously disposed of wastes (before 2008) located in the 200 West Area.

G.5.4.4.1 Waste Disposed of Before 2008

The sum-of-fractions of maximum potential concentrations as compared with benchmark MCLs for technetium-99 and iodine-129 for waste disposed of before 2008, as presented in Table G.46, are the same for all three alternative groups. Each waste category was evaluated as a separate entity because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category. Because of the higher waste containment integrity used for waste disposed of after 1995, waste releases of mobile constituents (that is, technetium-99 and iodine-129) to groundwater after 1995 would be delayed from release to groundwater from waste disposed of before or during 1995 by several hundred years.

Table G.46. Sum of MCL Fractions and Drinking Water Dose from Maximum Potential Concentrations for Technetium-99 and Iodine-129 for Waste Buried Before 2008 at Facility Boundaries

Primary Contributing Waste Category	200 East Area				200 West Area			
	Ratios of Maximum Potential Concentrations to Benchmark MCL			Estimated Dose (mrem/yr)	Ratios of Maximum Potential Concentrations to Benchmark MCL			Estimated Dose (mrem/yr)
	Tc-99	I-129	Sum-of-Fractions		Tc-99	I-129	Sum-of-Fractions	
Pre-1970 LLW	0.36	0.8	1.2	0.51	0.3	0.03	0.33	0.040
1970–1987 LLW	-	7.2	7.2	1.5	-	0.05	0.05	0.010
1988–1995 LLW	0.09	0.06	0.15	0.10	0.07	4.2	4.3	0.96
1996–2007 Cat 3 LLW								
Hanford Only	-	-	-	-	0.03	-	0.03	0.026
Upper Bound	-	-	-	-	0.03	-	0.03	0.026
1996–2007 MLLW								
Hanford Only	-	-	-	-	0.21	0.8	1.0	0.36
Upper Bound	0.27	1	1.3	0.47	0.12	0.5	0.67	0.21

The largest sum-of-fractions were calculated from maximum potential concentrations estimated for iodine-129 contained in 1970–1987 wastes disposed of in LLBGs in the 200 East Area and in 1988–1995 LLW disposed of in LLBGs (mainly 218-W-5 and 218-W-3A) in the 200 West Area. The arrival of maximum concentrations at the given LLWMA boundary were estimated to occur at about 90 years from the start of release, that is, about the year 1966, in the 200 East Area and at about 150 years from the start of release for wastes in the 200 West Area. These relatively short arrival times of maximum concentrations reflect the assumptions used in the release of waste disposed of before 1995, that is, using a relatively high infiltration rate of 5.0 cm/yr in waste release and vadose zone transport. The maximum concentration would be expected to persist at the LLWMA boundary for a relatively short period of time (a few decades) after initial arrival and would dissipate within the period of active institutional control (that is, 100 years after site closure), during which time ground water use within the Central Plateau would be restricted.

As may be seen from Table G.46, there are exceedances of benchmark MCLs using the sum-of-fractions rule; however, it may also be noted that drinking water doses are below the DOE benchmark drinking water standard of 4 mrem/yr at the the LLWMA boundary points of analysis.

G.5.4.4.2 Waste Disposed of After 2007

Combined ratios of maximum potential concentrations to benchmark MCLs for technetium-99 and iodine-129 for waste disposed of after 2007 are presented in Table G.47 for all three alternative groups. In this case, the wastes would be disposed of within the combined-use facility. They are evaluated separately from the wastes disposed of before 2008 because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category. Because of the improved waste isolation and containment used in disposal of waste between 1996 and 2007, releases of mobile constituents (that is, technetium-99 and iodine-129) from these wastes to groundwater would be separated from releases to groundwater from waste disposed of before 1996 by several hundred years. In addition, the use of a glass waste form for waste in ILAW would cause releases of mobile constituents from these wastes to groundwater to be separated from releases to groundwater from waste disposed of before 1996 by several thousand years.

For the three alternative groups considered, the calculated sum-of fractions would be lowest if the combined-use facility were sited near the PUREX Plant location. The higher levels of potential groundwater quality impacts at the 218-E-12B (Alternative Group D₂) and the ERDF (Alternative Group D₃) locations relative to the near-PUREX location (Alternative Group D₁) reflect differences in aquifer conditions found beneath the 218-E-12B LLBG (slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table) and the ERDF (lower hydraulic conductivities associated with the Ringold Formation at the water table) locations.

Similar to the results shown in Table G.46, there are exceedances of benchmark MCLs using the sum-of-fractions rule; however, again, it should be noted that drinking water doses are below the DOE benchmark drinking water standard of 4 mrem/yr at the the LLWMA boundary points of analysis.

G.6 Potential Groundwater Quality Impacts From Hazardous Chemicals in Pre-1988 Wastes

In response to comments received during the public comment periods on the drafts of the HSW EIS, efforts were made to develop an estimate of quantities of potentially hazardous chemicals in previously buried LLW so that potential impacts of such chemicals on groundwater quality could be evaluated.

G.6.1 Inventory Estimates

LLW disposed of prior to September 1987 does contain hazardous chemical constituents, but no specific requirements existed to account for or report the content of hazardous chemical constituents in this category of LLW. As a consequence, analysis of these constituents and estimated impacts based on the limited amount of information on estimated inventories and waste disposal locations would be subject to uncertainty at this time. These facilities are part of the LLW and MLLW facilities in LLW Management Areas 1 through 4 that currently are being monitored under RCRA interim status programs. Final closure or remedial investigation of these facilities under RCRA and/or CERCLA guidelines could involve further analysis of the potential impacts of the chemical components of these inventories.

Efforts were made to develop estimates of hazardous chemicals and their inventory quantities based hazardous chemical generation documented during the late 1980s. The estimation of these inventories, which used a waste stream analysis estimation method, is summarized in FH (2003).

The most substantial quantities of hazardous chemicals (in terms of inventory quantities) identified from this effort are summarized in Table G.48. These specific selected hazardous chemical inventories provided the basis for the following analysis of potential groundwater quality impacts from hazardous chemical inventories in wastes disposed of before 1988.

Table G.48. Estimated Inventories of Selected Hazardous Chemicals Potentially Disposed of in HSW LLBGs Between 1962 and 1987

Constituent	Inventory (kg)
Chromium	100
Fluoride	5,000 ^(a)
Nitrate	5,000 ^(b)
Lead	>600,000
Mercury	1000
1,1,1-trichloroethane	900
Xylene	3,000
Toluene	3,000
Methylene chloride	800
Oil	3,000
Diesel fuel	20,000
Hydraulic fluid	40,000
PCBs	8,000
(a) Fluoride mass equivalent for 10,000 kg of sodium fluoride.	
(b) Nitrate mass equivalent to 6,000 kg of sodium nitrate.	

G.6.2 Contaminant Group and Screening Analysis

As was done in the impact analysis for radiological constituents, the potential for each of the hazardous chemical constituents to impact groundwater was evaluated. Screening of these constituents evaluated their relative mobility in the subsurface system within a 10,000-year period of analysis. In addition, because of the presence of several organic chemicals in the table, the screening also considered the potential for chemical degradation within the period of analysis.

As in the radiological constituent analysis, the constituents were grouped based on their mobility in the vadose zone and underlying unconfined aquifer using estimated or assumed K_d for each constituent as a measure of mobility. A summary of all hazardous constituents using the same mobility groupings (based on K_d values) described in Section G.1.3.1 is provided in Table G.49.

The mobility of constituents in Table G.46 were further evaluated using estimates of constituent transport times through the thick vadose zone to the unconfined aquifer during the 10,000-year period of analysis described in Section G.1.3.1. Based on a natural infiltration rate of 0.5 cm/yr through the underlying vadose zone (see the screening analysis method described in Section G.1.3.1) and the estimated levels of sorption and associated retardation for each of the classes above, travel times of all constituents were estimated. Results of this analysis show that without a substantial driving force, arrival times of constituents within Mobility Classes 3, 4, and 5 through the thick vadose zone to the unconfined aquifer beneath the LLBGs were calculated to be well beyond the 10,000-year period of analysis. Thus all constituents in these classes were eliminated from further consideration. These constituents eliminated from further consideration included diesel fuel, hydraulic fluid, oil, lead, mercury, and PCBs.

Because the constituent list evaluated includes a few volatile organic chemicals, the effect of potential biotic and abiotic degradation and volatilization also were examined in the constituent screening process. Table G.50, which provides generic estimates of the biotic and abiotic degradation for selected chemicals, suggests that degradation, particularly biotic degradation, may be an important factor in reducing inventories of the organic constituents in question. Table G.51, which provides some laboratory estimates of volatilization rates, suggests that this process also would be important. Consideration of relatively high degradation and volatilization rates for the compounds in question provided the basis for eliminating the volatile organic chemicals within Mobility Class 1 including: 1,1,1-trichloroethane, xylene, toluene, and methylene chloride. No contaminants were identified in Mobility Class 2.

While these organic compounds would be expected to be reduced in source areas by the processes of degradation and volatilization, there is potential for an impact from breakdown products generated from degradation of the constituents in question. While these impacts were not evaluated in detail, the general types of byproduct compounds that could be formed were examined qualitatively to identify other potential constituents of concern.

Breakdown products from the above constituents may be produced from combinations of three subsurface processes. Two of these processes include biotic degradation by microorganisms under aerobic or anaerobic conditions. In the absence of viable microbial populations, abiotic degradation, which usually occurs as a result of chemical hydrolysis of the constituent, may also occur. Breakdown of

these constituents has generally established degradation pathways resulting in the formation of a number of intermediate breakdown products. Intermediate breakdown products that are regulated would be of most interest from an impact perspective.

A review of established degradation pathways for the four constituents (Jordan and Payne 1980; Truex et al. 2001; Vogel et al. 1987) identified two regulated byproducts of greatest potential concern: 1,1-dichloroethene and vinyl chloride, which would be associated with degradation of 1,1,1-trichloroethane. Methylene chloride produces chloromethane as a breakdown product (EPA 2000), but chloromethane is not regulated compound. Toluene and xylene produce breakdown products that are common constituents found in lignin (woody materials) and that break down in natural biological cycles. Such breakdown products are not regulated (EPA 2000).

The final list of constituents considered for further analysis included the remaining inorganic chemicals in Mobility Class 1: chromium, fluoride, and nitrate.

G.6.3 Analysis Methods and Other Key Assumptions

The following hypothetical groundwater quality impacts associated with hazardous chemicals contained in wastes disposed of before 1988 were based on the same source-term release and vadose transport calculations for in the main comparative analysis described in Sections G.1.3 and G.1.4 for this waste category. Little is known about the actual quantities and distribution of hazardous chemicals so the analysis of the estimated inventory for the selected constituents can only be considered a gross approximation of the potential impacts from these hazardous chemical in disposed of wastes. For purposes of these calculations, the entire hazardous chemical inventory was conservatively assumed to be uniformly disposed of in wastes contained within the 218-W-4B LLBG in the 200 West Area. The wastes currently disposed of in this LLBG are mostly wastes disposed of prior to 1970.

This analysis made use of the unit-release calculations for pre-1970 wastes in the local-scale groundwater model developed for the 200 West Area described in Section G.5.1. The underlying assumptions and analysis characteristics associated specifically with the analysis for pre-1970 LLW described in Section G.5.1 provided the basis for the results described here.

G.6.4 Summary of Results

Based on the constituent list and associated inventories developed for waste disposed of prior to 1988, summarized in Table G.48, potential groundwater quality impacts from hazardous chemicals are not expected to be substantial. A screening analysis that considered a combination of contamination mobility (due to sorption) and the potential contaminant degradation (due to biotic degradation and volatilization) reduced the starting lists of inorganic and organic constituents with the most substantial inventories to a list of three chemicals—chromium, fluoride, and nitrate.

For conditions where all of the estimated hazardous chemical inventories for these constituents are hypothetically emplaced in the 218-W-4B LLBG in the 200 West Area, estimated concentration levels at about 100 meters downgradient of the associated low-level waste management area (for example, LLWMA 3) were found to be below benchmark MCLs for all three chemicals (see Table G.52).

In actuality, waste disposed of before 1988 can be found within multiple burial grounds in the 200 East Area within the 218-E-10 and 218-E-12B LLBGs and in the 200 West Area primarily within the 218-W-4B, 218-W-4C, 218-W-3A, and 218-W-3AE LLBGs. Use of alternative assumptions that would distribute the estimated inventory to multiple LLBGs (rather than only in 218-W-4B) would result in further reductions in estimated concentration levels at aggregate LLWMA boundaries.

Final closure or remedial investigation of these facilities under RCRA and/or CERCLA guidelines eventually could involve further evaluation of historical waste records, more detailed waste characterization, and a more comprehensive analysis of the potential impacts of the chemical components of these inventories.

Table G.52. Predicted Peak Concentrations of Selected Hazardous Chemical Within Waste Disposed of Before 1988

Constituent	Benchmark MCL (mg/L)	Inventory (Kg)	Maximum Concentration ^(a) (mg/L)	Approximate Peak Arrival Time (yrs)
chromium	0.10	100	0.02	140
fluoride	4.0	5,000 ^(b)	1.0	140
nitrate	10.0 ^(c)	5,000 ^(d)	0.25 ^(e)	140
(a) Results are based on hypothetical disposal of these wastes in LLBG 218-W-4B in the 200 West Area, and concentration levels reflect levels estimated at about 100 m downgradient of the LLW Management Area 4 boundary.				
(b) Fluoride mass equivalent in 10,000 kg of sodium fluoride.				
(c) Benchmark MCL for nitrate is expressed as nitrogen.				
(d) Nitrate mass equivalent for 6,000 kg of sodium nitrate.				
(e) Concentration for nitrate is expressed as nitrogen.				